**Bird and Bat Migration over Appalachian Ridges**
**Progress Report, September 2007**

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**Background and Justification:**

Interest in developing wind power as an alternative renewable energy source has increased in recent years. In the eastern United States, exposed summits or ridge crests in the Appalachian Mountains have high wind power potential, and numerous wind power projects are being developed or proposed. While generally supportive of energy development from renewable sources, the U.S. Fish & Wildlife Service (FWS), state wildlife agencies, nongovernmental organizations, and the public are concerned about potential impacts of wind power development on wildlife. Large numbers of birds and bats cross or follow these landforms during their seasonal migrations, and wind power development potentially could impact populations of several species of concern. Baseline information on nocturnally migrating birds and bats has been collected at some wind power development sites in the Appalachians, generally within a single season. However, a stronger scientific basis is critically needed to assess and mitigate risks at a regional scale. This project implements a longer term collaborative regional study of the spatiotemporal distribution patterns and flight characteristics of birds and bats that migrate nocturnally through the Appalachian Mountains of the Mid-Atlantic states.

**Objectives:** The overall objective of the project is to increase our understanding of the characteristics and dynamics of nocturnal bird and bat migration through the Central Appalachians, so that informed and scientifically sound recommendations can be made to reduce the risk to migrants of proposed and operational wind power projects. Specific objectives include:

1) Document broad-scale patterns of nocturnal migration through the region.
2) Document site-specific passage rates/densities, flight direction, and flight altitudes of migrating birds and bats.
3) Obtain site-specific information on the identity and relative abundance of bird species that call while migrating.
4) Model the effects of weather, topography, or other variables on migrant densities and flight characteristics.
5) Map observed and predicted migrant densities to identify locations where/when migrants might be at risk from wind power development.

**Progress:** Work to date has focused on collecting and processing data to assess both broad-scale and site-specific patterns of nocturnal migration through the region.

**1. Broad-scale patterns**—Broad-scale patterns of nocturnal migration through the region are being assessed through analysis of weather surveillance radar (NEXRAD) data. Radar images for nights during the Fall 2004 and Spring 2005 migrations from four NEXRAD stations (Pittsburgh, PA; Charleston, WV;

Roanoke, VA; Knoxville, TN) were screened to identify those with targets that likely are migrating birds (Principal Investigator Sarah Mabey). Nightly densities and flight directions of migrating birds were assessed from radar reflectivity and radial velocity data, respectively, to describe the distribution and movements of migrants as they approach and move through the Appalachians. Data have been downloaded and converted to GIS format so they can be overlaid on digital topographic data.

In contrast to regions with little topographic relief, the movements of migrants through the study region appear to be quite disorganized, possibly in response to mountain ridges or other prominent landforms. Topographic blockages to each NEXRAD station's radar beam are being mapped to aid in determining whether this indicates a response of migrants to topography, and to delineate the geographic areas with and without radar coverage. Note that even when unimpeded by topography, NEXRAD cannot detect bird targets within its full range (about 230 km) because the antenna is set at a tilt. As a consequence, the radar beam is above the maximum flight altitude for the majority of migrating birds at a distance of about 110 km from each radar, so NEXRAD coverage of migration through the region is very incomplete.

**2. Site-specific patterns**—Although NEXRAD data provide information on the broad-scale spatial and temporal patterns of nocturnal migration through the region, these radars generally do not detect bird or bat targets within the altitudinal zone potentially occupied by wind turbines. Therefore, we have employed two complementary ground-based techniques, acoustic detection and portable radar sampling, to obtain site-specific information on the abundance and flight characteristics of nocturnal migrants in the lower airspace.

**Acoustic monitoring**—We have continued collecting acoustic data during both the spring and fall migration periods of 2007, recording the calls made by migrating birds in flight to index their abundance. Two additional sites were established on Big Savage Mountain, MD, bringing the total number of sites with recording units (Figure 1) to 31 (Figure 2). Sites are openings on ridges, knobs, slopes, or valleys, on lands owned by the USDA Forest Service (George Washington and Jefferson National Forests [GWJNF], Monongahela National Forest [MNF]), FWS (Canaan Valley National Wildlife Refuge), the states, or The Nature Conservancy (TNC). In Spring 2007, recording units were operational from approximately 8 April through 31 May. We set them out again during 10-14 August, and will remove them from the field in early November. We have been able to maintain a schedule of bi-weekly visits this season, and have had minimal disturbance (so far) by animals, so coverage will be more complete than in previous falls. This likely will be our last field season, giving us three falls and two springs with acoustic data from these sites.

We have been working diligently on processing and analyzing the recordings, focusing first on those from 2006. This is a multi-step process that first involves identifying and clipping out the night-time segments from the recordings (our recording units record sounds continuously, 24:7). We then scan them for flight calls using XBAT, sound analysis software developed by Harold Figueroa and Matt Robbins of the Bioacoustics Research Program (BRP), Cornell Lab of Ornithology (CLO). An XBAT extension, developed by Kathy Cortopassi of BRP, searches for and flags sounds of a user-specified range of durations within a user-specified range of frequencies; spectrograms of sounds flagged by this detector are then reviewed to eliminate those that are not bird calls. Sound files can also be scrolled through manually, with flight call spectrograms selected and output. Calls are identified to species, when possible, by matching them to a reference set (Evans, W.R., and M. O'Brien. 2002. Flight Calls of Migratory Birds: Eastern North American Landbirds. Old Bird, Inc.). For each hour of sampling at each site, recorded calls are tallied, to index migrant abundance within and among nights. This effort has been helped tremendously by the assistance since April of Jo Anna Leachman, hired as a contractor through IAP. Jo Anna, who's based at the University of Maryland's Appalachian Laboratory in Frostburg, MD, has concurrently been finishing her master's thesis; her project included the collection of acoustic data at six sites in western MD during the spring and fall migrations of 2005 and 2006, so she has considerable experience with extracting and identifying flight calls from sound recordings.

We have not yet summarized results for distribution, or related the counts to weather or other variables, so cannot yet comment on patterns in migrant abundance or factors that influence them. In general, considerably more flight calls are recorded at these sites during the fall migration than in spring, and in both seasons there is considerable variation among nights, both within and among sites. Although we have identified some calls to species, most can only be placed in species groups (e.g., warblers, sparrows, thrushes) because their spectrograms are not clear, likely because many of the calls are made by birds flying at the outer limits of recording (the microphones can record calls up to about 300 m above ground level). We hope to finish the 2006 recordings this winter, so will include summaries and preliminary analysis results in a project progress report to be prepared next spring.

In addition to flight calls, our recordings are rich in other sounds. The day-time recordings, particularly from spring, provide great listening (!), and information on arrival dates of migratory species and on the species composition of both the migrant and resident bird communities at the sites. In going through the night-time segments, we have detected the calls or songs of Saw-whet Owls at some WV sites (Briery Knob, Scenic Highway, Sharp Knob), Whip-poor-wills from at least two VA sites (Locher Tract and Ratcliff Place), and American Woodcock at many sites, so have an extensive sound archive that could be analyzed to document call or song patterns of these species, and how they're influenced by time of night or season, weather conditions, moon phase, or other variables. Along that vein, we've recently launched Project Katydid. Under the advisement of Deanna and PWRC biologist Sam Droege, Madeline Frank, a student in the Science and Technology Program at Eleanor Roosevelt High School in Greenbelt (MD), is sampling fall recordings from Backbone Mountain to get calling patterns for Northern True Katydids. She'll relate these to weather variables from a nearby MD Dept. of Transportation weather station, which collects and archives weather data several times each hour.

Figure 1. Recording unit, Nelson Sods, Pike Knob Preserve (TNC), Pocahontas Co., WV. Microphones, two per unit, are nestled in PVC housings covered by shag wind screens. Sounds are recorded onto an mp3 recorder with 100 GB hard drive, housed in a weather-tight access box mounted on a bucket that holds the batteries.

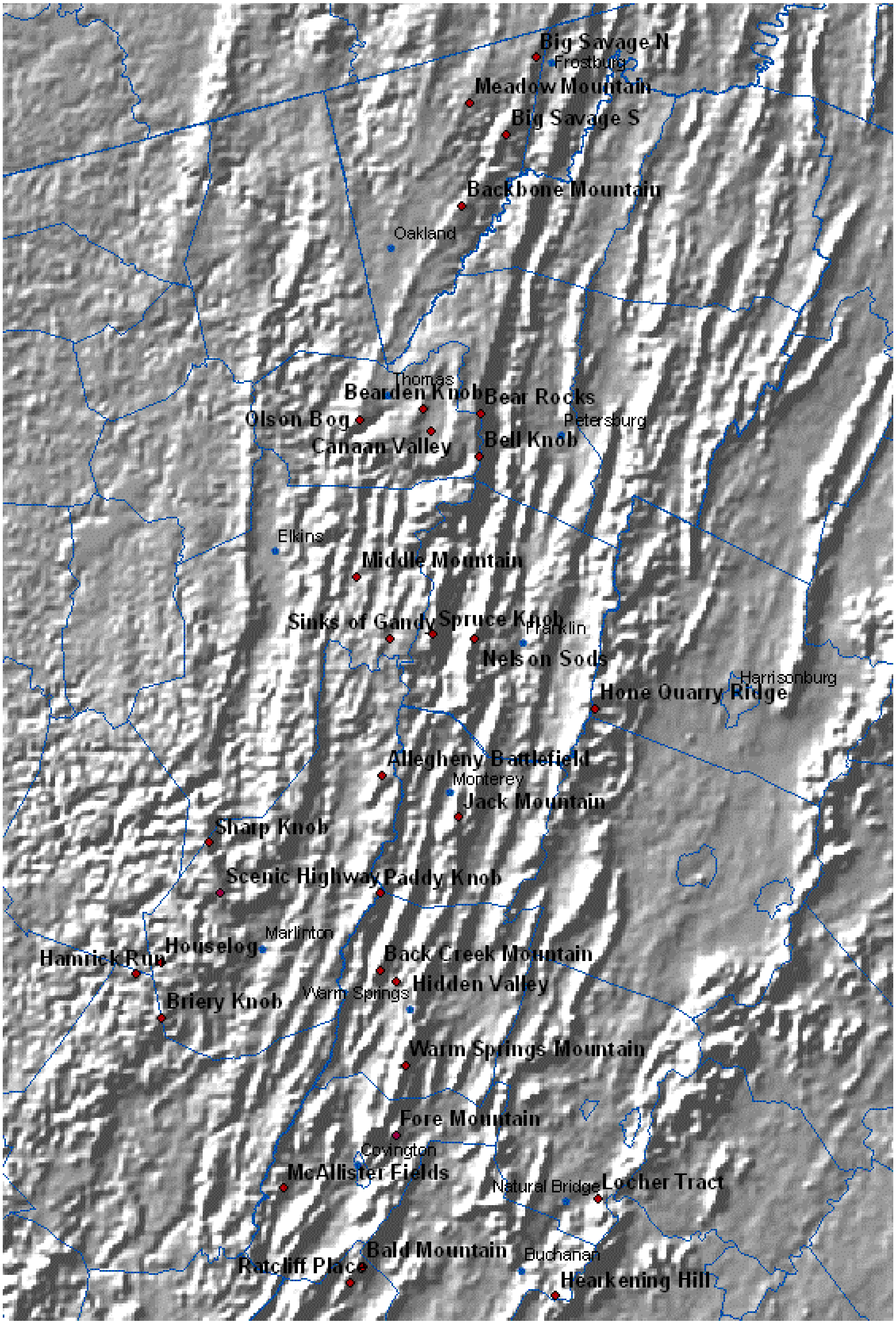

Figure 2. Acoustic monitoring sites in the Central Appalachians, 2007.

**Portable radar sampling**—In 2006, portable radar sampling was conducted by New Jersey Audubon Society (NJAS, Principal Investigator David Mizrahi) during both spring and fall at three ridge-top sites (Backbone Mountain, Potomac State Forest, Garrett Co., MD; Jack Mountain, Highland Wildlife Management Area, Highland Co., VA; Sharp Knob, MNF, Pocahontas Co., WV; Figure 2) where migrating birds were also monitored acoustically. At each site, radar data were collected on a total of 12 nights in Spring 2006, grouped in four 3-night sessions spaced at roughly 1-week intervals between 15 April and 24 May, and on a total of 18 nights in Fall 2006, grouped in 4- or 3-day sessions between 16 August and 17 October. On each sampling night, data collection started at sunset and continued until approximately sunrise the following morning. Two X-band marine radars were used concurrently, one with antenna mounted in the horizontal plane (surveillance mode) and set to detect targets (birds and/or bats) out to 2.75 km, the other with antenna mounted in the vertical plane to sample the altitudinal distribution of targets up to 1.4 km above ground level, encompassing the flight altitudes of most migrating songbirds. Five successive data images were automatically captured and archived every 10 min for every hour the radar was operated. Data on target numbers, altitude, speed, and direction were extracted from each radar image, using software developed by NJAS staff, and summarized for each hour of sampling. We had hoped to conduct portable radar sampling in additional seasons, but project funds were insufficient to allow it.

Analysis of the portable radar data is nearly complete, and a final report should soon be forthcoming from NJAS. Preliminary analysis of the Spring 2006 vertical radar data showed considerable variation among nights in the number of targets detected and their altitudinal distribution, with about 40% of all targets $\leq$ 300 m above radar level (ARL). 13% of the targets detected were flying within 100 m ARL, and 16% 100-200 m ARL.

In Fall 2006, trial visual observations were made concurrent with the radar sampling, counting the numbers of birds and bats passing through an upright light beam shielded with an infra-red filter, as a way to estimate the proportion of radar targets in the lower airspace that likely are bats. Bats are extremely difficult to sample during migration, and we have otherwise been unable to collect specific information on them. They cannot be clearly distinguished from birds by the radar, and specialized detectors are needed to record their calls, which are above the range of frequencies recorded by our microphones. It remains that the extent to which bats echolocate or otherwise call during migration is still poorly understood by bat experts. Alternative methods for detecting bats, such as through the use of thermal imagery, cannot yet be practically used to sample bat migration across a wide geographic area. For this species group, it is critical that post-construction monitoring be done at wind power projects, to better understand the conditions under which migrating bats are vulnerable to strikes by turbine blades so that effective mitigation measures can be identified and implemented.

**3. Outreach**—Presentations on the project were made at several meetings. In October 2006, Deanna gave presentations at the PWRC Biennial Science Meeting and at the USGS-USFWS workshop ‘Applying Radar Technology to Migratory Bird Conservation and Management: Strengthening and Expanding a Collaborative Effort’, held in Albuquerque, NM. Tim spoke at a meeting of the PA Wind Collaborative in January 2007. In addition, a project poster made by Deanna was displayed at the PWRC Science Meeting, at the wildlife research meeting of the National Wind Coordinating Collaborative, and at the Wildlife & Wind Energy Conference at Kutztown (PA) University. Deanna also assisted with development of a PWRC webpage on wind energy research (http://www.pwrc.usgs.gov/resshow/windpower/), where the poster and other (eventually) project products are on display.

**Plans for FY2008:**

Additional NEXRAD data will be analyzed, for nights during Spring and Fall 2006 (Principal Investigator David Mizrahi). Migration intensity and flight direction at four NEXRAD stations (Pittsburgh, Charleston, Roanoke, and Sterling, VA) will be assessed and compared. This will give us coverage of the 2006 migration periods by all three sampling techniques (NEXRAD, portable radar, and acoustic detection) and, combined with the NEXRAD data for Fall 2004 and Spring 2005, NEXRAD’s view of the spatial and temporal patterns in nocturnal migration during four different seasons.

At this time, we do not plan to conduct field sampling in additional seasons, but will focus on processing and analyzing the acoustic and radar data. Acoustic and portable radar estimates of migrant abundance will be compared in order to develop, if possible, an adjustment to the acoustic data that can be applied at sites where radar sampling was not conducted. For 2006, correspondence in temporal migration patterns, as documented by the three sampling techniques will be assessed, to evaluate their comparability in sampling nocturnal migration. For the portable radar data, circular statistics will be used to determine mean flight direction relative to each study site and how it is affected by prevailing wind conditions; the altitudinal distribution of migrants will be characterized under different migration density scenarios (e.g., low versus high) and weather conditions. For data from all sampling techniques, multivariate regression techniques or, possibly, hierarchical analysis will be used to model the effects of weather, site or landscape characteristics, time of night or season, or other variables on migrant density, mean or minimum flight altitude, or mean flight direction. These analyses collectively will allow us to understand migrant flight dynamics and behavior and conditions that influence them. Predicted migrant densities and flight characteristics will be mapped region-wide as a function of topographic characteristics, and densities will be summed across dates within seasons to identify locations over which large numbers of migrants pass, or pass at altitudes within the sweep reach of wind turbine rotors, either consistently or occasionally. This information will be used to develop a summary map of areas where the risk of migrant interactions with potential wind power projects is expected to be low, moderate, or high.

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